

SEVERE ACCIDENTAL HEAD INJURY

An Assessment of Long-term Prognosis



A.H. Roberts

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A large, stylized, outlined letter 'M' logo, positioned at the bottom left of the page. The letter is rendered in a classic, serif font with a double-line outline, giving it a three-dimensional appearance.

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Foreword

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This book is published at a most opportune time for those concerned in the study of head injuries. There have been significant advances in recent years, not only in our understanding of the underlying physiological and pathological changes that may follow injury, but also in management. They include the demonstration of the pathology of concussion; the use of controlled ventilation to prevent hypoxia and to assist in the maintenance of normal intracranial pressure; the introduction of computerised axial tomography as a non-invasive examination in the diagnosis of some complicating factors after head injury, particularly intracranial haematoma; the recognition of the metabolic and hormonal changes that may follow severe brain injury. These and other factors have placed into the hands of doctors valuable adjuncts to the diagnosis of head injury and the prevention and management of potentially fatal complications.

The questions being asked now, however, concern not only what effect these changes have on the mortality rate, but after severe head injury what is the quality of life for those who survive? Can we predict what is likely to happen at various intervals following injury, and what measures are required to mitigate the long-term effects among the survivors?

One approach to answering these questions is provided in this book based on a meticulous study of a series of consecutive head injuries followed up for periods from ten to twenty-five years. The survey was conducted, not by those concerned in the acute management, but by an independent team headed by Dr Anthony Roberts, Consultant Neurologist in London, and assisted by Mrs Dorothy Weir, Psychiatric Social Worker, and Dr Eileen Smith, Clinical Psychologist. It says much for their dedication that of the 548 patients studied, all but 11 were traced after such long periods of time.

In this book the reader will find some useful prognostic factors which should help him in trying to answer some of the difficult questions doctors ask themselves, as do the patients and their relatives. The survey graphically demonstrates the practical recovery many patients can make, especially the young; but it also emphasises in poignant fashion the problems and difficulties a family may face when one of their number is left with major mental and/or physical disability. The challenge to doctors from the evidence provided is the implication that the ultimate result may depend not only on the severity of the initial injuries, but on the treatment given in the immediate period afterwards when time is of the essence and when some complications can be prevented and others treated before irreversible changes take place.

The closing chapters of this book emphasise the rising tide of patients, mainly young people, left either totally dependent on others or severely disabled. Is society fully aware of the need to make adequate provision for their care, and will the evidence stimulate us to re-examine our rehabilitation programmes and to attend to the mental needs of patients and their relatives with as much energy that some expend on purely physical rehabilitation?

I am personally very grateful to Dr Roberts for undertaking this research and for providing for all of us concerned in the management of head injuries much that will be useful in the care of patients, and pointers to some of the changes that are so urgently required in the future if we are to raise our standards of care.

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In Miss Kathleen Dyer I have had the good fortune to have had helping me, in two epidemiological studies of head injury, a former nursing sister, medical librarian and bibliographer equipped with a first class degree in modern languages. It is a pleasure to acknowledge my very considerable debt to her and my gratitude.

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1 Introduction

The past 30 years has seen, in most developed countries, a steady increase in the proportion of the population who can expect to suffer head injury. At the same time, improvements in techniques of resuscitation and in the management and effective treatment of some of the complications of head injury have salvaged a progressively larger number of the more severely brain-damaged who would previously have had no chance of surviving their injury.

The greater proportion of those involved in accidents which cause head injury are healthy adolescents and young adults who, at the time of the injury, have a further life expectancy of a half century or more in the normal course of events. There must therefore be a substantial and steadily enlarging population of more or less disabled survivors of head injury making increasing demands on the societies in which they live. Despite this there is still surprisingly little information about this important and almost certainly underprivileged minority group within the community.

The published facts do not provide a clear idea to what extent the various disabilities characteristic of brain damage due to closed head injury may be expected to resolve or become modified in the long term, or how often and in what form they are likely to persist indefinitely. There is little information about the ultimate prospects for the more severely disabled and less on life expectancy. What there is tends to be conflicting since it has usually been based on heterogeneous series of patients selected by criteria which are difficult to compare and often poorly defined.

It is generally held that as much recovery of function as is going to take place after brain tissue has been destroyed is likely to have done so in the course of a year or so. It is a common observation that the rate of recovery of function after brain injury declines exponentially with time, but to determine at what stage it ceases, or when it can be assumed that no further modification of disordered function can be expected, requires the assessment of residual disability in an unbiased sample from an unselected population of head-injured patients followed over many years.

In addition, any assessment of post-traumatic neural disability must attempt a separate examination of the contributions to the overall incapacity made by impaired memory and other intellectual functions, and by personality disorder, as well as by physical disability. Such information is available in some detail in a number of studies of war wounded, but this kind of population is highly contaminated by patients with penetrating brain wounds due to small, high-velocity missiles. The damage caused by these missiles is unlike the diffuse acceleration injury to the brain which occurs in the more common closed head injuries of accidents. Studies of the long-term disabilities of wartime brain injury may relate to those of closed head injury caused by

accidents, but this can only be decided when comparable data are available from both sources.

The prospect of analysing in great detail functional disturbances caused by the discrete focal brain injury of high-velocity missiles has encouraged a number of exceptionally well-designed studies of this type of head injury in relation to traumatic personality disorder, impaired intellectual function and memory, as well as in the coarser field of disordered sensory perception, motor function and epilepsy. There have been few attempts to define patterns of disordered neural function after closed head injury, and even fewer designed to examine the relationship between disabilities still demonstrable many years afterwards and the individual characteristics of the head injury. This has been so despite the theoretical, experimental and pathological evidence that the brain damage in closed head injury, although diffuse, is usually most severe in polar and medial temporal and orbitofrontal areas of the brain, and that there is a predictable relationship to the site of head impact.

In a study of the cumulative effects of repeated minor head injuries in a random selection of boxers examined many years after the end of their professional careers, the author noted a relatively stereotyped clinical syndrome. This suggested damage preferentially to areas of the brain concerned with memory, together with an asymmetrical distribution of the intensity of the injury in cerebellar and pyramidal systems. A striking feature of this pattern of lesions was the frequency with which signs of pyramidal damage were more marked in the left limbs. This observation, which was also seen to have been made by others when earlier reports of boxers' encephalopathy were analysed in detail, is undoubtedly related to the fact that in boxing there is a tendency for more and harder blows to be struck by the right fist to the left side of the head. It seemed likely that if this were apparent after repeated minor head injury, there may be a more accurately predictable relationship in severe closed head injury between the side of head impact and post-traumatic disorders of intellectual function and perhaps of personality, as well as weakness and ataxia of the limbs.

The undeniable disadvantages of retrospective studies are lessened when the aim is the assessment of the ultimate outlook for disabilities which result from severe head injury. Questions of prediction which concern the surgeon in his management of the patient in the first hours or days after head injury are not the same as those posed for the physician who is attempting, several weeks or months later, to assess the most opportune time to introduce the available techniques of physical or mental, and finally social and occupational, rehabilitation. And they hardly concern those advising on the problem of appropriate financial compensation for disabilities likely to persist. In viewing the natural history of the effects of brain damage in head injury it is easier to see the evolution of a pattern of disability if the information about the acute and convalescent stages can be compared with the state of the patient examined years later, shorn of the distracting problems of acute management.

The study described in this monograph was designed to examine the relationship between the type and severity of non-missile head injury and early neurological sequelae, and the final degree and characteristics of mental and physical disability between 3 and 25 years later in two groups of patients. The first, a consecutive series, included every patient remaining unconscious or amnesic for a week or longer from a total population of 7000 patients admitted after head injury to the Accident Service of the Radcliffe Infirmary, Oxford between 1948 and 1961. This was for practical purposes a random sample, and estimates based on these figures are made for the numbers similarly disabled after head injury annually in England and Wales in the final chapter. To these patients were added a smaller selected series of the most severely head injured, drawn from other sources, who had remained unconscious for longer than a month after injury.

Details of the acute and convalescent stages after injury were abstracted from the uniformly well-documented case records of neurosurgical units with a particular interest in the management of head injuries. Of the total series of 548 patients only 11 were lost to the survey and the rest were followed up and re-examined, or the cause and time of death were established. In each case the persisting intellectual, personality and neural deficits found, and the disabilities these caused in the spheres of domestic social and occupational life were assessed. In nearly 90 per cent of cases a similarly detailed account was obtained from one or more relatives. The majority were also examined by a neuropsychologist using tests of intellectual function designed to demonstrate memory and intellectual functional deficits lateralised to one or other cerebral hemisphere.

A computer-assisted analysis of the data made it possible to describe patterns of residual neural lesions, often predictably related to the severity and complications of the injury and to the side of head impact in the less severely injured, and to suggest probable pathological correlations; to predict, in most cases within weeks of injury, the final degree and character of personality disorder, intellectual deficit and neural disability to be expected in the long term, and the rate at which recovery is likely to take place; to make estimates of life expectancy and examine the natural history of post-traumatic epilepsy; and to deny the entity of a specific neuronal degeneration due to a single head injury. Each of these topics is considered separately, as the titles of the chapters indicate, and discussed in the light of earlier studies. They follow a review of previous publications on the general subject of long-term prognosis after severe closed head injury, and in the appendix there are examples of case records illustrating the patterns of mental and physical disability that were found.

2 Previous Reports of Long-term Outcome

This chapter provides a critical survey of those previous reports in which the design of the investigation and methods of assessment were sufficiently clearly described to make possible comparisons with the present study. There is also a voluminous literature on the general topic of the neurology, pathology and mechanics of closed head injury to which reference is made in the relevant chapters.

Unfortunately, methods of assessment and criteria for the selection of patients, and even the interpretation of 'long-term' and 'severe', vary so widely in these reports that it is impossible to present all the information adequately in tabular form alone: more extended discussion is necessary. The following account comments on similarities and differences, and also on inadequacies or limitations of method or selection criteria, whilst at the same time drawing attention to the numbers of patients studied on which conclusions have been based.

The reports are reviewed in order of their comparability with the present study, the most closely comparable first. There is further subdivision into three sections reflecting the selection criteria employed in each case. The first section deals with those papers in which the severity of the injury has been estimated indirectly by the duration of coma or post-traumatic amnesia, or by the characteristics of the neurological state during the acute traumatic period. The second reviews papers in which the selection of patients has been made on the basis of the severity of physical disability requiring physiotherapeutic rehabilitation in convalescence. In the third section age has been the primary criterion for selection, and those reports are reviewed which are concerned with the long-term outcome of severe closed head injury in children. Finally, brief reference is made to a few studies which, although reporting only the short-term outcome, examine issues highly relevant to the general problem of prediction.

Selection of Patients by Criteria of Severity of Injury

The most closely comparable study, so far as attempts to examine individually the various disabling sequelae are concerned, is that reported by Fahy, Irving and Millac (1967). In this a rather idiosyncratic criterion of severity was used for the selection of the patients. This was that the state of the patient on admission to hospital had been such as to indicate the need for burr-hole exploration. This was normally done in any patient in coma who did not 'show and sustain signs of improvement within a short time of admission'. Sixty-seven consecutively injured patients were selected, excluding cases with

depressed skull fractures, and also three patients who, in retrospect, were thought to have had injuries insufficiently severe to warrant the surgical exploration to which they had been submitted. The 32 survivors were traced 6 years after their injury. The cause of death for the six who were found to have died was established and all but two of the remaining 26 who were still alive were personally examined by the authors. There is no comment as to the duration of coma, but the post-traumatic amnesia had exceeded 3 days in all cases, the mean post-traumatic amnesia being 5 weeks. The brain had been seen to be contused or lacerated in nearly half the cases and there was surface brain compression in more than a third.

In assessing the outcome the authors considered neurological disability, psychiatric aspects, post-concussional symptoms, epilepsy and work capacity separately. It was found that a third of the patients were without neurological signs, and that recovery from hemiparesis or bilateral spasticity was good, so that in the five patients with persisting hemiparesis disability was slight and the majority had only residual changes in tendon reflexes and plantar responses. A disturbance of gait, due in a third of the cases to cerebellar damage, and in two patients to spasticity of the legs, was mild. A sensory deficit was demonstrable in only two cases and it was limited to patchy impairment of perception of pain. The most severe neurological disability was due not to central neural damage, but to a peripheral brachial plexus lesion. Complaints of speech disturbance were apparently frequent, but it is not clear whether in most instances this was due to a defect of articulation rather than dysphasia. One patient still had a mild naming difficulty. Residual cranial nerve lesions were limited to a complete loss of sense of smell in three instances, unilateral optic nerve damage in three others and mild oculomotor impairment in two.

So far as psychiatric sequelae were concerned less than a quarter of those examined were judged to be symptom-free, and half were demented, assessed by tests of intellectual function. The remaining quarter were forgetful but not sufficiently so for this to be demonstrable in psychometric tests of memory. A schizophreniform psychosis developed in one demented patient, and two of the forgetful ones had paranoid delusional illnesses. In others disinhibition, moods of depression and a variety of 'angry and depressive feelings' were said to be in contrast to their previous personalities. One patient became prone to outbursts of violence and another was considered to have become introverted and obsessional. There were two patients who were considered to have undergone welcome changes in personality as a result of their injuries. Impaired concentration and increased irritability were common, but the association of these two symptoms with complaints of headache, giddiness and intolerance of noise, as is characteristic of the so-called post-concussional syndrome, was not encountered.

It was shown that there was increasing neurological and psychiatric disability with longer post-traumatic amnesia, and that psychiatric disability was greater than neurological. Neither was severe when the amnesia had lasted for

only 2 weeks. Half of those whose post-traumatic amnesia had lasted for 7 weeks were left with severe disabilities in both spheres. No significant relationships were found between neuropsychiatric disability and age, or duration of coma, although no statement was made as to the period of coma the patients had experienced. All informants reported that disabilities improved during the first 2 years, this improvement still continuing in a third of the patients at 4 years. The mortality rate amongst the survivors discharged from hospital was six times that expected in a normal population of similar age, and half of these had died severely demented in mental hospitals. A fifth of the survivors were unemployed at the time of the examination but half of the remainder were earning as much as before injury. Full employment with some reduction in earning capacity was possible despite quite severe physical disability. Objective measures of social adjustment seemed to bear little relation to clinical findings. It was not apparent to the authors how the outcome 6 years later might have been predicted on the information available in the year of the injury.

A number of other studies have been reported in the last 10 years in which the design and methods of investigation have been similar but, because there has been selection bias, the information derived from them is open to more criticism. Miller and Stern (1965) selected 100 consecutive patients, who had been referred to one of them, on average 3 years after injury, for medical assessment in connection with claims for compensation. Ninety-two survivors were then re-examined between 3 and 40 years later. In each case the post-traumatic amnesia had lasted for more than 24 hours. It was found that, of the four who had died in the interval, in only one case was death related to the head injury. This had been due to poisoning by coal gas which the patient could not smell. Residual psychiatric symptoms were present in about 15 per cent. Rather more than half of these showed some degree of dementia. A further four patients were to some extent disabled by neurotic anxiety and depression, two being constitutionally predisposed. Evidence of focal brain injury, demonstrable at the first examination in a quarter of the series as a spastic weakness on one or both sides was found persisting in only four patients at the time of the follow-up studies. Limb ataxia persisted in only one, and hemisensory loss in none. No patient had residual dysphasia. Impairment of cranial nerve function was still evident in most cases where the first, second and eighth nerves were involved, although to what extent and what disability this caused is not mentioned. Post-traumatic epilepsy developed in almost a fifth of these patients and most remained liable to fits. Three were still having frequent attacks despite anticonvulsant medication. The occupational status of a quarter of the men had declined as a result of their injury, about a third of these because of permanent brain damage, and in the majority of the rest as a result of 'impairment of efficiency' not otherwise specified. Epilepsy was contributory to this downgrading in six patients. All the children had recovered completely and all the women seemed to have been capable of looking after their homes, although how efficiently is not stated. These authors do not comment on factors affecting prognosis amongst their patients.

In a more recent paper, Lundholm, Jepsen and Thornval (1975) selected a consecutive series of 54 patients who had been unconscious for more than a week after injury, and re-examined the 30 survivors between 8 and 14 years later. There were three injuries complicated by surface brain compression; the remaining patients were considered to have suffered cerebral contusion. Their social rehabilitation was graded as independent, dependent in some degree upon their families or an institution but able to take care of their personal needs, or helpless and requiring permanent institutional care. The grade of rehabilitation was examined in relation to persisting neurological and intellectual functional impairment. Varying degrees of paresis persisted in all three groups, but no more severely amongst those who were completely dependent than amongst those who were not. On the other hand amongst the quarter of the patients with severe mental impairment none was socially independent; half were independent but only one of these was over the age of forty at the time of his injury. The length of coma within each age group was another determinant of outcome. Coma exceeding a month precluded rehabilitation if the injury occurred over the age of twenty. It was considered that all of the patients exhibited some intellectual impairment, and two-thirds 'an abnormal behaviour pattern' not otherwise qualified.

A small number of patients whose head injuries had caused coma lasting for at least 3 weeks were followed up by van der Zwan (1969). In this report he reviews the same series of patients followed for a shorter time 5 years earlier and described in greater detail by Lambooy, van der Zwan and Fossen (1965). In defining their concept of grades of coma they assess as conscious patients who were 'following with the eyes' and note that of the 14 unconscious for longer than 2 months, half died, whilst all the survivors remained 'severely disabled'. Of the 44 patients selected, more than a third were either dead or not available for examination, but the remaining 27 patients were examined personally by the authors. In a quarter of these surface compression by intercranial bleeding had complicated the injury and a tracheostomy had been required in nearly every case. Neurological abnormalities due to central lesions caused a persisting hemi- or monoparesis in a third of the patients and in two cases these were still severely disabling. A third of the cases were affected by incoordination and in half of these there was a paresis of the legs. Akinesia tended to be more disabling than paralysis. In half the patients speech was a flat monotone. There was little demonstrable sensory loss, but what there was tended to be associated with severe hemiparesis. Evidence of disturbed endocrine function was present in only one case and this solely on account of obesity. There was persisting anosmia, or an optic nerve lesion, in over a third, and residual facial paralysis in another third. Eighth nerve function remained impaired in nearly half. In all the patients there was a marked slowness of thought, speech and movement which varied in degree. Tests of memory were impaired in two-thirds, and a third were to some extent dysphasic. In general the prevalence of residual disabilities due to central neural lesions doubled where the coma lasted for longer than a month. This was not found to be so in the case of intellectual impairment assessed by

psychometric tests, nor in the case of behaviour disorders. These latter were reminiscent of the effects of standard leucotomies. A quarter were socially dependent, another quarter were able to earn a living but at a reduced level, and the remaining patients had not changed their social status.

In a large number of reports of the long-term outcome the period of follow-up has ranged extensively from a few months to several years and the value of the assessments is for this reason open to criticism. A careful clinical study was made by Frowein, Haar, Terhaag, Kinzel and Wieck (1968) based on a consecutive series of 132 patients who had been unconscious for longer than 2 days. Unconsciousness, precisely defined, was considered to last until the patient kept his eyes open in response to painful stimuli or command, or until he carried out specific movements on command. One quarter of the patients were lost to the survey and the remaining 100 were followed up between 1 and 13 years later, half for no more than 6 years. Residual neurological disability consisting of severe paresis was present in a quarter of all the patients followed up, and slight pareses were present in another tenth. Where this type of neural disability was severe it was associated with considerable limitation in work capacity. Slight paralyses recovered within 6 months, and increasingly longer periods were needed before the final level of improvement was reached in the more severe forms. In some children improvement continued for 5 years. The striking improvement in spastic paresis commented on by Miller and Stern (1965) was observed in only one case. In adults paresis could take 3 years to recover, but there was rarely significant improvement thereafter.

A series of tests held to assess various aspects of intellectual and personality deterioration, as designed by Kinzel (1968), was used in a random sample of 38 per cent of the patients studied by Frowein *et al.* It would appear from the authors' diagrams that, overall, there was a positive correlation between low test scores and poor occupational rehabilitation. To a lesser extent there was the same relationship with duration of coma. The euphoria exhibited by many of the severely damaged patients often tended to be misleading in the assessment of outcome. An analysis was made of the relationship between duration of coma and capacity for work. It was concluded that, for children, normal or only slightly limited working capacity would follow coma prolonged for 3 weeks, but for adults up to the age of forty-five years 1 week was the limit, and for those older, no more than 4 days. In only a quarter of the patients, of whom over half were under the age of twenty, was the working capacity judged to be normal, and in severe cases it took as long as 4 years to reach this level of rehabilitation. In the case of the more severely damaged patients rehabilitation in some kind of sheltered employment was not achieved until 9 years after the injury.

In a consecutive series of 308 patients who had suffered what is described as 'severe cerebral injuries' with and without fracture of the skull, Sölch and Schyra (1972) examined the relationship between the duration of unconsciousness, three grades of severity of the injury and the outcome 2-20 years

later. Severity was assessed by considering the time needed for the initial neurological defect to regress. Those who regained their mobility early on had fewer neurological signs when followed up. It is not clear what proportion of the survivors were followed up or how many were personally examined. They noted, as have preceding authors, that three-quarters of the patients could be considered to have recovered from their injury and that disability in the remainder was due mainly to personality change, intellectual deficits and epilepsy. Most of the patients under the age of twenty years regained their capacity to work, and proportionately larger numbers failed to do this as age increased. The duration of coma, not otherwise defined, similarly affected occupational status. Unconsciousness persisting 3 days and more resulted in some limitation of the capacity to work normally in the majority. Dementia was rare and massive cerebral deficits were seldom seen. On the other hand, what they describe as 'micro-symptoms', which include clinical signs of pyramidal tract lesions, were common and still present in over a third when re-examined. Fewer than a tenth had actual paresis of a limb. The intellectual and psychiatric symptoms were the most severe consequences of the injury which persisted. The most striking was a general slowing down of thought processes with defects of day-to-day memory, loss of initiative and irritability. This was noted in about a fifth of the cases. Severe frontal personality change was present, with some degree of dementia, in about a tenth of their patients. The authors review the evidence which suggests that many of these sequelae are due, not to primary traumatic brain damage, but to a number of interacting factors such as predisposition, raised intracranial pressure and secondary lesions.

Selecting on the basis of coma lasting for longer than a month, Lecuire, Deruty, Dechaume and Lapras (1973) followed 37 survivors of 69 patients for a period of over 18 months. The authors did not define precisely their concept of coma but they note that most of their patients required tracheostomy and many needed assisted respiration. They observe in general terms that both age and length of coma determine prognosis. Despite neurological deficits the larger proportion of their patients was able to take up paid work again. Disorders of personality and intellectual function typically included impairment of memory and concentration and of the ability to make sustained intellectual effort. This was usually associated with irritability, aggression and emotional instability. This characteristic constellation of disordered mentality frequently 'compromised rehabilitation' even when neurological and intellectual functions were otherwise relatively unimpaired.

A study of 100 consecutive patients who had suffered a head injury defined as severe, in that they had been unable to answer or obey for longer than 9 days, was reported by Obrador, Bustos and Fernandez-Ruiz (1973). They were re-examined between 8 months and 7 years later. Rather less than a third had undergone surgical removal of contused or lacerated temporal or frontal poles, or evacuation of compressive surface collections of blood or fluid. A close relationship was shown to exist between the length of post-

traumatic amnesia and the duration of unconsciousness, or what the authors prefer to describe in terms of varying grades of 'subreactivity'. Three-quarters were found to have some degree of major neurological deficit. This was severe in less than a tenth, and a quarter also had sensory defects. A third were dysphasic in some degree and two-thirds had defective 'recent memory'. It was the authors' impression that the likelihood of further recovery of neural function after 3 years was remote. Increasing age, duration of post-traumatic amnesia and the duration of 'subreactivity', that is, impaired response to stimulation after the injury, was associated with an increasing prevalence of intellectual defects as tested, and with a decline in occupational status. Substantially less than a quarter had returned to their former occupations at the time they were followed up, but there is no comment on how long this was in each case. A return to some form of work was usual in patients below the age of forty whose post-traumatic amnesia had lasted for less than 40 days. No patient over the age of forty at the time of injury was able to work normally again. In most cases recovery sufficient to enable the patient to return to work had taken place within a year – if it were going to.

Selection by Criteria of Severity of Persisting Physical Disability in Convalescence

In all the previous reports selection has been by an indirect criterion of severity of the injury based upon the duration of traumatic amnesia, coma or altered consciousness, or, in the first paper, by a somewhat less easily comparable assessment of the need for burr-hole exploration because of deterioration or lack of improvement in conscious level and neural responsiveness.

A well-documented study of 170 patients selected from amongst 617 who still had severe disabilities at the time of discharge from hospital or several months later, was reported by Vigouroux, Baurand, Choux and Guillermain (1972). These were followed up between 1 and 12 years later. Over half of the patients did not reply to the appeal to collaborate, and of the 352 who did, it would seem, although this is nowhere clearly stated, that all were examined personally by the authors. The 182 they judged to be almost normal were excluded from the study. Case reports of the 14 individuals most seriously disabled, survivors of modern methods of resuscitation, are given in detail. Amongst these there were three whose neurological state is described as '*végétative*', one being still alive 11 years after injury. There were two able to make semipurposive movement of a limb whose level of consciousness was such as to suggest some contact with their environment, but it is doubtful whether these were more than primitive automatisms.

The authors describe in some detail the characteristics of disordered motor function, cranial nerve deficits, and clinically demonstrable defects of intellectual function which they found amongst the remaining 156 patients. In only